THE ENVIRONMENTAL TECHNOLOGY VERIFICATION PROGRAM

U.S. Environmental Protection Agency

SOUTHERN RESEARCH INSTITUTE

ETV Joint Verification Statement - Phase II

TECHNOLOGY TYPE:	**ROD PACKING STATIC SEALING DEVICE**
APPLICATION:	**SECONDARY SEALING SYSTEM FOR RECIPROCATING COMPRESSOR ROD SEALS DURING STANDBY OPERATIONS**
TECHNOLOGY NAME:	**Static-Pac™**
COMPANY:	**C. Lee Cook Division, Dover Resources, Inc.**
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The U.S. Environmental Protection Agency (EPA) has created the Environmental Technology Verification (ETV) Program to facilitate the deployment of innovative or improved environmental technologies through performance verification and dissemination of information. The goal of the ETV Program is to further environmental protection by substantially accelerating the acceptance and use of improved and cost-effective technologies. ETV seeks to achieve this goal by providing high quality, peer reviewed data on technology performance to those involved in the purchase, design, distribution, financing, permitting, and use of environmental technologies.

ETV works in partnership with recognized standards and testing organizations, stakeholder groups that consist of buyers, vendor organizations, and regulators, and with the full participation of individual technology developers. The program evaluates the performance of technologies by developing test plans that are responsive to the needs of stakeholders, conducting field or laboratory tests, collecting and analyzing data, and preparing peer reviewed reports. All evaluations are conducted in accordance with rigorous quality assurance protocols to ensure that data of known and adequate quality are generated and that the results are defensible.

The Greenhouse Gas (GHG) Technology Verification Center (the Center), one of 12 technology areas under ETV, is operated by Southern Research Institute, in cooperation with EPA's National Risk Management Research Laboratory. The Center has recently completed the Phase II evaluation of the performance of the Static-Pac™ System offered by C. Lee Cook Division, Dover Resources, Inc. This verification statement provides a summary of the test results for the Phase II verification of the Static-Pac system performance.

TECHNOLOGY DESCRIPTION

In the natural gas industry, methane leaks from reciprocating compressors occur from several sources, including blowdown valves, rod packing, unit isolation valves, pressure relief valves, and other small fugitive sources. A large source of these emissions is gas leaks from compressor rod packing. Gas can leak from compressor rod packing while the compressor is in operation and, in some cases, when the compressor is in pressurized standby mode. Pressurized standby operating mode is commonly encountered in the industry, and is done to ensure that compressors can quickly return to operation in response to changing pipeline demand. If rod leaks during standby operations are reduced or eliminated, significant gas savings and emissions reductions could occur. The C. Lee Cook Static-Pac device is intended to provide this benefit.

The Static-Pac is a gas leak containment device designed to prevent rod packing leaks from escaping into the atmosphere during pressurized compressor standby periods. The Static-Pac system is installed in a conventional packing case by replacing several rings (typically two) in the low-pressure side of the packing case. Upon shutdown of the compressor, the compressor control system activates the Static-Pac control system and a pressurized gas is used to move a piston along the outer shell of the Static-Pac seal, wedging a lip seal into contact with the rod. This lip seal reduces leakage from the rod packing. When the actuating pressure is lowered, the piston retracts, releasing the Static-Pac seal.

VERIFICATION DESCRIPTION

The Static-Pac was verified at a natural gas compressor station operated by ANR Pipeline Company. The test was carried out on two engines (8-cylinder, 2000 hp), each equipped with two reciprocating compressors operating in parallel (4-inch diameter rods). The evaluation focused on two shutdown/standby mode procedures that represent the most common approaches to compressor shutdown. The two procedures are: (1) the compressors remain pressurized during standby periods and compressor blowdown is not conducted, and (2) the compressors are depressurized (the gas is vented to atmosphere via the blowdown vent) before standby.

The Phase I Verification Statement was issued in September 1999 and evaluated installation costs and initial gas savings. The goals of Phase II were to verify additional performance parameters: (1) annual Static-Pac gas savings and methane emission reductions, and (2) Static-Pac payback period. Prior to Phase I, the Static-Pac was installed on a single rod on each of the two engines. The remaining rods, equipped with conventional packing, served as Control Rods against which Static-Pac performance was compared. The Control Rod packing was outfitted with new seals at the same time the new Static-Pac seals were installed, facilitating a more direct comparison between the Test and Control Rods. Emissions from other equipment whose leak rates are affected by the standby mode were also measured; these include the blowdown valve, pressure relief valve, unit isolation valves, and other miscellaneous sources that impact gas savings.

To accomplish the Phase II verification, additional rod leak and miscellaneous engine component measurements were collected between September 21, 1999, and January 27, 2000. The conclusions presented in this statement are based on direct measurements made during both phases of testing, station operational logs, cost and O&M data submitted by site operators and C. Lee Cook, projections of engine operating schedules and emission rate trends determined by the Center, and industry average emissions data documented in other studies. Static-Pac emission reduction performance is based on 32 measurements that span the time from when the packing was installed to a point at which approximately 4,000 hours of wear had occurred. Emission rates were determined using a Flow Tube designed and calibrated by the Center. The Flow Tube employed a thermal anemometer for low flow detection in the range of 0.02 to 1.0 scfm, and a vane anemometer to measure higher flow rates in the range of 0.2 to 6.0 scfm. All flow measurement instrumentation was laboratory calibrated before and after each sampling event using a laminar flow element (LFE). The LFEs were also laboratory calibrated with National Institute of Standards and Technology (NIST) traceable primary standards.

The Phase II verification test design, measurement procedures, and quality assurance/quality control (QA/QC) procedures are characterized in the following Test Plan: *Testing and Quality Assurance Plan for the C. Lee Cook Division, Dover Corporation Static-Pac™ System, July 20, 1999*. During the Phase I testing, several changes were made to the sampling approach proposed in the Test Plan. These changes are documented in the Phase I Report. Phase II verification results may be found in the report titled *Environmental Technology Verification Report, C. Lee Cook Division, Dover Resources, Inc. Static-Pac™ System, Phase II*. Both documents have been reviewed by C. Lee Cook, ANR Pipeline Company, selected members of the Center's Oil and Gas Industry Stakeholder Group, and the EPA QA Team. The reports, as well as the Phase I Verification report, may be downloaded from the ETV Program or Center web sites (www.epa.gov/etv or www.sri-rtp.com).

VERIFICATION OF PERFORMANCE

At the conclusion of the Phase II verification testing, it was clear that emissions from the host site compressors were atypically low when compared to average emissions documented in other studies by the Gas Research Institute (GRI) and the Pipeline Research Committee (PRC). The compressors tested with conventional packing had very low leak rates, the engines had relatively low standby rates, and the test engines were equipped with only two compressors each. Each of these variables contributed to an overall annual gas emission rate that was atypically low. To address this and present a more representative evaluation of Static-Pac performance, the Center used the GRI and PRC data to estimate annual gas savings and Static-Pac payback for compressors with industry average emission rates.

In this Verification Statement, gas savings are presented as measured on the test compressors. They are also estimated for industry average compressor systems based on industry average rod leak rates (0.9 to 1.9 scfm), engine standby rates (approximately 55 percent), and numbers of compressors per engine (three compressors per engine). In addition, the Verification Report gives estimates of gas savings and payback for a matrix of several typical rod packing leak rates, engine standby rates, and numbers of compressors associated with a given engine.

Verification Performance: During the Phase I and Phase II evaluations of the Static-Pac, the following results were determined:

- Methane Emissions During Standby: On average, the Static-Pac reduced 96 percent of the rod packing emissions while the compressor was in a standby, pressurized state. The overall average methane emission reduction achieved at the test site was 0.49 scfm methane/Static-Pac equipped rod.

- Natural Gas Savings for a Compressor that Normally Remains Pressurized During Standby Periods: For the test site, the average natural gas savings rate achieved with the Static-Pac was 0.50 scfm, or approximately 96 percent of the gas that would have leaked from the conventional packing. This is equivalent to 30 scf of natural gas savings/standby hour for each Test Rod. The test engines had an average standby time of 38.5 percent during the calendar year and averaged 37 shutdowns. For a two-compressor engine with these features, annual gas savings of 204,000 scf of natural gas would be achieved with the use of the Static-Pac. The Center extrapolated these results to an industry average engine/compressor system (three compressors, standby rate of 55 percent, rod leak rates of 0.9 to 1.9 scfm), and estimated that annual gas savings with the Static-Pac ranged from 749,000 to 1,582,000 scf of natural gas.

- Natural Gas Savings for a Compressor that Normally Depressurizes and Blows Down to Atmospheric Pressure: As a result of changing from a blowdown practice to a pressurized standby condition, significant gas savings can result from blowdown volumes and unit valve leaks. The annual gas savings from these components are 1,247,062 scf of natural gas. The change in operating practice can also result in emission increases from other components now exposed to high pressures, including the rod packing. With the Static-Pac installed, some small rod packing leaks continue to occur. The net annual gas savings for two-compressor rod engines that eliminate the blowdown practice and are installed with Static-Pacs are 1,239,372 scf of natural gas. The changes in operating practice, particularly those due to the elimination of the blowdown volume, provided all the reductions. Without the Static-Pac, an additional 211,690 scf of natural gas would be leaking from the rod packing during pressurized standby.

- Installed and O&M Costs: The costs for modifying the test rod with the Static-Pac and installing a single automatic actuator system on each test engine were determined to be $3,483 per engine. For engines with multiple compressors, the costs are extrapolated to be $4,808 and $6,133 for two and three Static-Pac equipped rods, respectively. For these compressor/engine systems, one common actuator system is required to control the Static-Pacs. Operation and Maintenance (O&M) costs for the test site were determined to be negligible based on observations and discussions with three ANR compressor facilities which collectively represent a history of 57 Static-Pacs operating for 1 to 16 years. For a small population of these Static-Pacs, the Static-Pac equipped rods required replacement parts in Years 11 through 15 due to malfunctioning compressor rods (one-time capital cost of $500 to $800 per rod).

- Static-Pac Payback Period: Static-Pac payback was calculated using a natural gas price of $2 per thousand cubic feet. The Center's Oil and Gas Industry Stakeholders identified this price as that typically used during the past decade when conducting technology evaluations. The Center recognizes that recent increases in natural gas prices may result in a change in this figure. The reader may want to consider current prices when conducting evaluations for a specific Static-Pac application. The payback period for the host site was over 30 years because of the atypically low rod leak rates encountered. Using the annual gas savings associated with industry average rod leak rates of 0.9 and 1.9 scfm, the Static-Pac payback is estimated to be 5.5 and 2.3 years, respectively. If these compressors require Static-Pac replacement parts as stated above, the payback period increases by about 3 months. It should be recognized that these results are representative of facilities that exhibit characteristics similar to ANR sites. The payback matrix in the Verification Report presents a variety of payback periods estimated by varying the rod packing leak rates, engine standby rates, and numbers of compressors.

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